

The University of Chicago

THE UNCOMPAHGRE VALLEY IRRIGATION PROJECT

A PART OF A DISSERTATION SUBMITTED TO
THE FACULTY OF THE DIVISION OF THE
PHYSICAL SCIENCES IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF GEOGRAPHY

1939

By

HAROLD A. HOFFMEISTER

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I. THE GENERAL SETTING

The Uncompahgre Valley Irrigation Project, comprising approximately seventy-two thousand acres of irrigable land along the Uncompahgre River in western Colorado (Fig. 1), represents a costly attempt of the Federal Government to convert an arid district into an area of profitable agriculture.

Irrigation is indispensable to agricultural production in this intermontane valley, where the annual rainfall of ten inches is insufficient for crops, even if dry-farming methods are used. Although the valley has an altitude of more than five thousand feet, temperature conditions provide a growing season amply long for practically all crops common to the Middle West. The pioneer farmers learned that the soils on the broad, flattish mesa tops and valley bottoms were highly productive wherever irrigation water could be supplied.

Water for irrigation was obtained in early days from the Uncompahgre River. This river, which rises a few miles south of the project, was small and its flow erratic. Although approximately thirty thousand acres normally were irrigated, the water supply was inadequate and unreliable. In periods of drought, only holders of priority water-rights could secure enough water. The owners of secondary water-rights, denied the necessary water at such times, found their crops damaged. In spite of these limitations, the farmers were producing satisfactory crops and raising large numbers of livestock. An air of prosperity and well-being pervaded the valley.

Farmers and ranchers of the valley were finding markets for their commodities, and it was believed that additional produce could be disposed of readily. Mining camps in the nearby mountains were booming and needed flour, meat, vegetables, and other supplies produced in the valley. Transportation facilities were available. Access to eastern and Pacific markets was provided by a standard-gauge branch of the Denver and Rio Grande Western Railroad from its main line at Grand Junction (Fig. 1). A narrow-gauge branch of the same railroad from Salida passed through Montrose to mining towns

Note: The following pages contain the essential portion of a dissertation of 180 pages, including 62 maps, graphs, and pictures, and 39 tables. The complete dissertation is to be found in the University of Chicago Libraries.

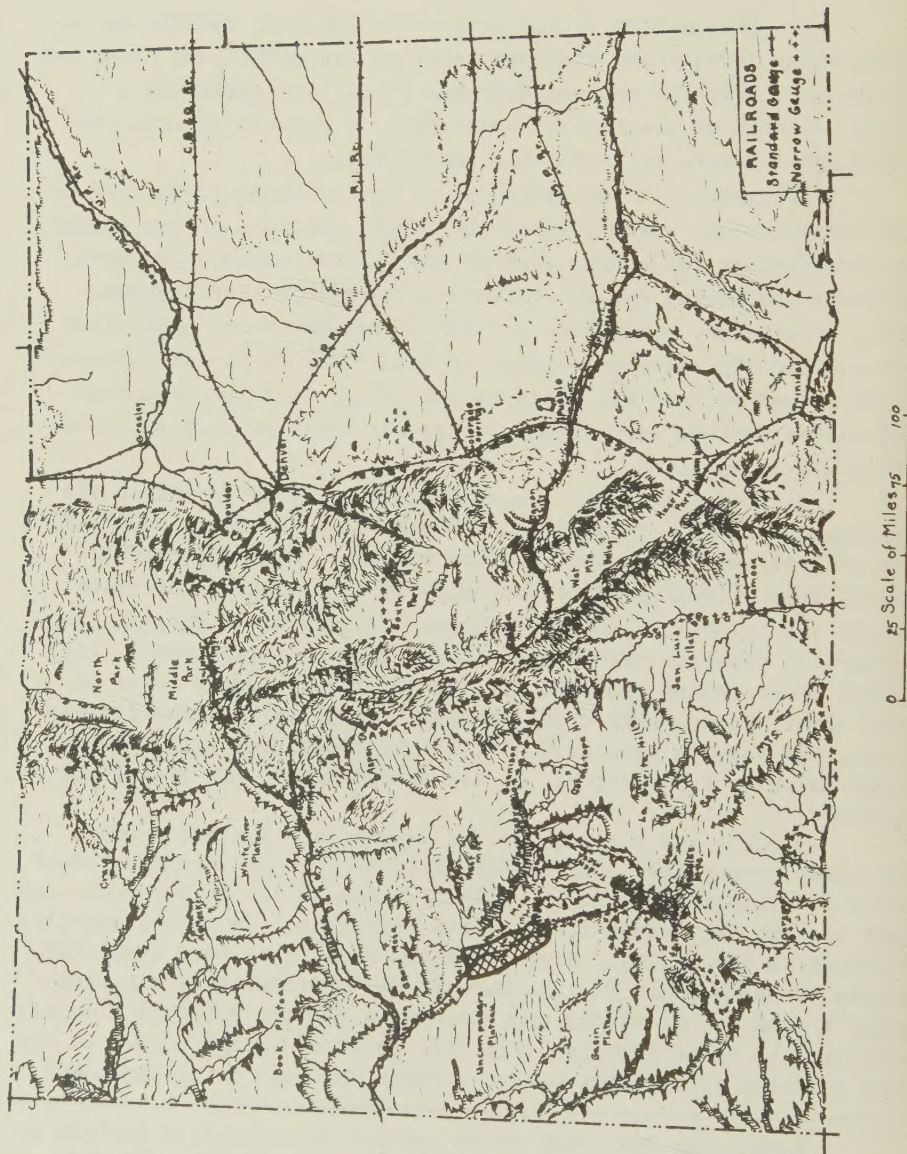


Fig. 1.—Map of Colorado, showing the position of the Incomeshare Project

in the mountains south of the valley. Several state and national highways afforded facilities for local trading. Progress was thought to be checked only by lack of an adequate water supply.

The Gunnison River, on the northeastern side of Vernal Mesa, had a large flow, but there was no irrigable land along its deep, steep-sided canyon (Fig. 2). The possibility of diverting water from the Gunnison into the fertile valley of the Uncompahgre was often talked of by local engineers, but the cost of such an undertaking was too great for either the local community or the State to finance it. After several years of intensive propaganda, the project was brought to the attention of the Government.

The United States Bureau of Reclamation took over the work of reclaiming the Uncompahgre Valley in June, 1904, and the difficult task of diverting water from the Gunnison into the valley was started immediately. A tunnel, six miles long, through the intervening rocks of Vernal Mesa (Fig. 2), and an extensive canal system were constructed. Water was first delivered to the project lands during 1910, but not all of the engineering features of the project were completed until more than two decades later.

This eight million dollar reclamation experiment was one of the earlier projects attempted under the National Reclamation Act of June, 1902. The Act provided that the proceeds of the sale of public lands should constitute a fund for the reclamation of arid and semi-arid lands. The cost of reclamation was to be borne by the projects involved and was to be repaid to the fund, without interest, within ten years. In addition, each project was supposed to bear the costs of operating and maintaining its irrigation system. The Government was to turn over the system to the project farmers when the latter had met their obligations.

Public land on the Uncompahgre project was thrown open to homesteaders and privately owned land was subdivided. It was assumed that homeseekers would flock to the project and that the area would be converted into small, intensively cultivated farms. Newspapers throughout the country carried glowing accounts of the "wonderful productivity of these reclaimed lands" and the ease of establishing homes in this "garden spot." As a result, people from most sections and from many occupations came into the area.

An airplane trip over the project today would afford a view of the valley as it appears almost three decades after the project was taken over by the Government. It is an oasis surrounded by

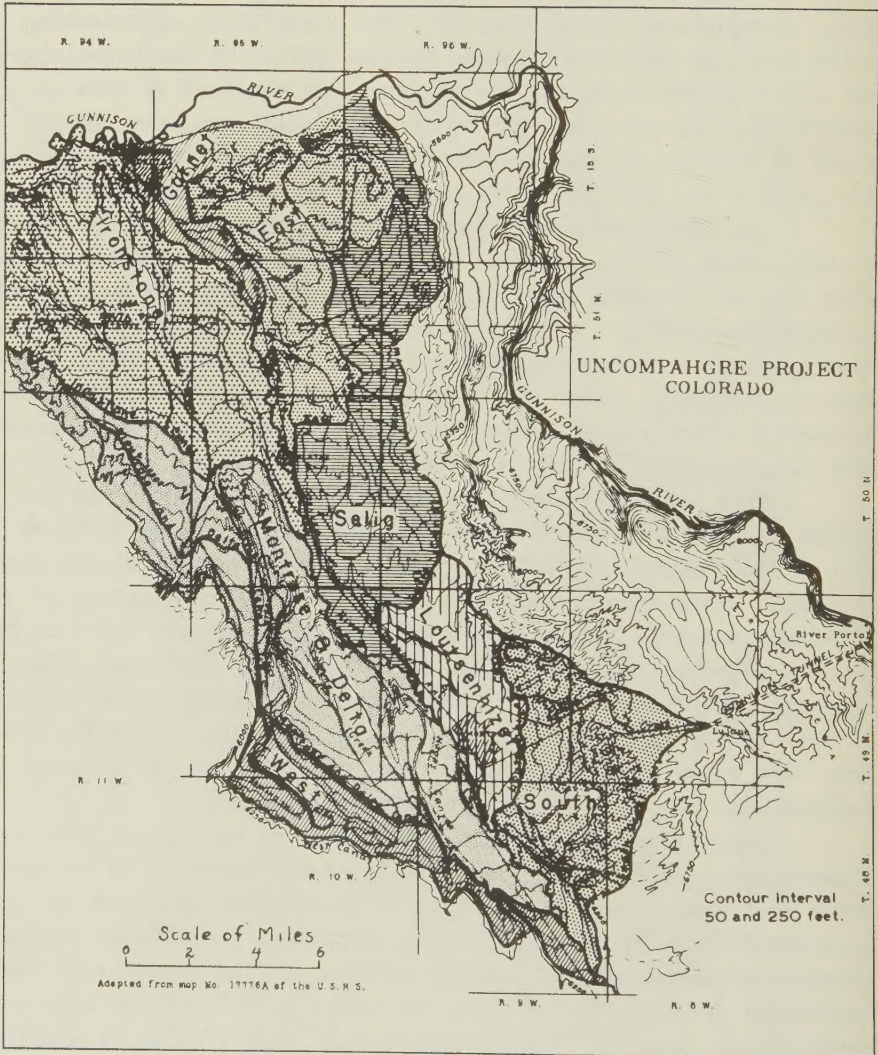


Fig. 2.--The Uncompahgre Project, showing the layout of the irrigation systems.

barren hills of shale. These eroded hills, with only scattered patches of sage, cacti, and cedar, have an appearance of desolation. Purple mesas mount higher and higher far into the west. The bare, multicolored, dissected wall of the great mesa on the east stands in sharp contrast to the bold-faced mesa on the north, which, dark and forbidding, rises some four thousand feet above the valley. On the south and southeast are broken, jagged peaks, which form part of the snow-capped Continental Divide.

The abraided Uncompahgre River, flanked by groves of green trees, meanders through the center of the oasis. At irregular intervals large canals diverge from the river, carrying water to neighboring lands. Extending along the borders of the project and practically surrounding it are other primary canals, which have received water directly from the Gunnison Tunnel and the South Canal (Fig. 2). A network of lateral canals and ditches, which distribute water from the primary canals, is spread over the area.

The valley below is by no means one continuous garden spot. The tilled areas are patchy in distribution and are separated one from another by large pastures, unused areas, or waste lands (Fig. 3). Much of the land appears to be little used. These areas stand out distinctly from the cropped lands. In places they surround tilled fields and in other places are surrounded by them. The most extensive of these areas are the so-called "seepy" lands, where an excess of ground water has made the soil so moist and so highly impregnated with alkaline salts that cultivation is impracticable. Alkali flats, on which heavy accumulations of salt have killed all plant life, occupy a surprisingly large part of the valley. The dirty glistening salts, splotted over the brownish soil, afford little hope that these sections will ever be reclaimed. Less desolate in appearance, but almost as worthless, are the large areas of "Chico," or land covered with greasewood, which stretch for miles in several parts of the valley.

The towns, Montrose, Olathe, and Delta, situated respectively in the southern, central, and northern parts of the project (Fig. 2), have an appearance of enterprise and progress. The rectangular street patterns, the abundance of trees, and the dispersion of the houses are typical features of towns of similar size in Colorado. The conspicuous clusters of feeding-pens and corrals along the railroad sidings indicate the importance of the region as a cattle country. In Montrose and Delta, courthouses show that

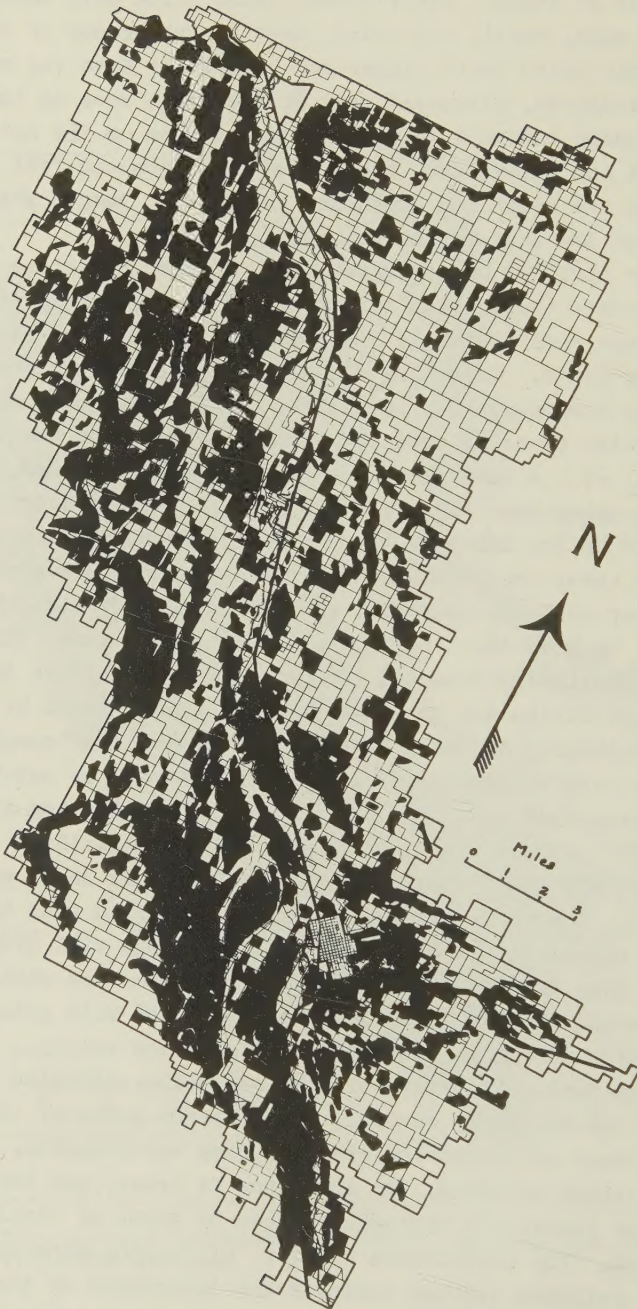


Fig. 3.--Distribution of cropped land on the project

they are the political centers of the counties bearing their names. Grain elevators, flour mills, and warehouses are to be seen in all three towns, for these communities are market places for the surrounding country.

On closer examination, it is evident that the Uncompahgre project has proved to be a disappointment, economically and socially. Perhaps from an engineering viewpoint it has been successful. There is no doubt, however, that poorly-planned, ill-advised, or ill-fated features of the construction, operation, and maintenance of the system contributed to the lack of success which characterizes the project as a whole.

Today, twenty-eight years after the Government took over the task of reclaiming the valley, the project has repaid only \$490,112 of the total \$7,937,000 originally due the Reclamation Fund. The original period of ten years in which it was expected that the costs would be repaid to the Fund by water users was soon found to be too short. Subsequent legislation extended the repayment period until 1962. In 1932 the Government reduced the repayment obligations to a probable total of \$3,366,797. Even with these aids and inducements, many doubt whether the project can ever be liquidated and believe the Government will be forced soon or later to cancel the entire debt of the project. In many years the farmers have failed to meet the operation and maintenance charges. The estimates of the irrigable area have been reduced, little by little, from 146,000 acres to approximately 72,000 (Class 1) acres. Of this estimated area fewer than 60,000 acres are being irrigated. Thus, the heavy capital outlay has added only approximately 30,000 acres of irrigated land to the acreage previously irrigated. Population has increased from about 6,700 to approximately 13,359 as a result of the reclamation venture. About 75 per cent of the added population settled on farms and the remainder in the towns. The project cost approximately \$225 per irrigated acre, and approximately \$1,100 per person added to the population of the valley.

Mortgage indebtedness has increased rapidly, and today 55 per cent of the project land is mortgaged at an average of \$67.14 per acre, or at an average of \$3,197 per encumbered farm. Each year the percentage of tenants to owners working the farms is increasing; almost 50 per cent of the farmers are tenants or hired workers who farm nearly 50 per cent of the irrigated land.

The present study is an analysis of the factors which have contributed to the unsatisfactory state of the project. It is an analysis of:

1. Those adjustments, mainly of an engineering character, made in the construction, operation, and maintenance of the irrigation system, which permitted an enlarged agricultural productivity, together with those maladjustments which helped to make the final costs much greater than originally anticipated.
2. The various adjustments made by the settlers in their endeavor to secure a living in this modified environment, together with those maladjustments in their activities which have contributed to their unsatisfactory economic position.

II. CONSTRUCTION FEATURES OF THE PROJECT

The National Reclamation Act of June 17, 1902, made it possible for the residents of the Uncompahgre Valley to secure governmental aid in promoting their irrigation venture. The Act provided for the construction and maintenance of irrigation works for the storage, diversion, and development of waters for the reclamation of arid and semi-arid lands in sixteen western States. The Secretary of the Interior was directed to divide the benefited land on reclamation projects into farm blocks of a size that would support an average size family. The estimated cost of an irrigation project was to be returned to the Reclamation Fund by the water-users in not more than ten annual installments. On June 7, 1904, the Secretary of the Interior authorized the Uncompahgre Project, and bids were called for on its construction features.

A contract for construction of the proposed tunnel was entered into between the Government and the Taylor-Moore Construction Company on October 18, 1904, which called for completion of the tunnel in 1908 at a cost of \$1,000,000. The financial weakness of the company was soon revealed, yet the warning was ignored, and on November 21, 1904, at the request of the Uncompahgre Valley Water Users Association, the Government reduced the bonds of the company from \$150,000 to \$100,000 so that it could start work. The company could not complete its work, and on May 12, 1905, it surrendered the contract, having fulfilled but a small part of its obligations. No effort to collect damages from the bondholders of the company was made by the Government for many years. Finally in 1920, a judgment of \$22,500 was secured and credited to the project,

but this represented only a small fraction of the losses suffered by project farmers as a result of the failure of the company.

The Water Users Association persuaded the Secretary of the Interior to complete the construction work under the supervision of Government engineers. In an effort to relieve the bondsmen from their obligations, the Government decided to use the machinery and equipment of the defunct company. It later was shown that a material saving would have been made if the steam power plant and equipment at River Portal had been abandoned and electric power had been generated at Lujane (Fig. 2).

The tunnel was excavated from four headings; one group worked westward from River Portal, another worked eastward from Lujane, and two groups worked in opposite directions from a shaft sunk into the center of the mesa. The tunnel is 30,583 feet in length, and although originally designed to carry 1,300 cubic feet of water per second, is capable of carrying only 900 second-feet. The tunnel slopes uniformly towards the Uncompahgre Valley at a grade of 2.02 feet per thousand feet.

The geologic formations encountered in the tunnel were complex and presented an endless succession of problems. Heavy flows of water, sometimes so hot that the workmen were driven out of the heading, discharges of gas, caving and movements of rock along the shear planes in faulted zones repeatedly delayed progress and raised the cost of the construction much above the estimates. The four headings were connected in July, 1909, and the work of lining the tunnel was begun, but this had not been completed by 1934.

Under the original plan of the project, the Government was to construct the tunnel, a diversion dam in the Gunnison, the South canal, connecting the tunnel with the Uncompahgre River, and two canals known as the East and West canals (Fig. 2). The project farmers were to unify the land in the valley through the sale of 100,000 shares of stock in the newly organized Water Users Association. Each acre of land entitled the owner to one share of stock at a cost of one dollar per share, with an assessment limit of twenty-four dollars. The Association was to secure control of all existing canals in the valley and to construct new canals where needed to insure an adequate distribution of water.

The estimates of the costs of the features to be constructed by the Government varied from \$2,000,000 to \$2,500,000. This

cost would have meant a water charge of twenty-five dollars an acre, and many farmers refused to join the Association. Although officials of the Government gave assurance that this sum was the maximum charge for which the farmers could be held liable, it became necessary for the officers of the Association to carry on a farm to farm campaign, soliciting subscriptions to the Association.

That the farmers were sincere in their belief that an ample supply of water would be furnished them at a cost of not more than, and probably much less than, twenty-five dollars an acre is unquestioned. There is abundant evidence to show that they were led to this belief by representatives of the Government. It has been alleged that the Government, when it was later shown that the costs would be much higher than originally estimated, exerted pressure on the farmers who refused to vote for an amendment to the Articles of the Association removing the limitation of assessment on the land. As many farmers were in dire straits, they reluctantly allowed the Association to impose a higher water charge.

It is impossible to determine the final costs of all items included in the original contract between the Government and the Association. Some features have not been completed and many plans have been altered. The failure of the Association, in 1906, to secure the existing canals and to construct the additional ones needed for the distribution system forced the Government to enlarge the scope of its work. As a result, the costs of the original features are mixed inextricably with the costs of the added features. However, the final cost of the Gunnison Tunnel, the diversion dam, and the South Canal was \$4,008,258. This is almost twice the original estimate, which also included the cost of the East and West Canals.

The final cost of those features originally undertaken by the Government, excluding the East and West canals, would have resulted in a charge of \$40.08 per acre, on the basis of 100,000 irrigable acres, in contrast to \$25.00 per acre which most farmers believed to be the maximum charge. However, the estimates of the irrigable area have been changed repeatedly, a circumstance which complicates the problem of making comparisons. The latest estimate gives the project only 72,036 acres. Therefore, the charge would have been \$55.49 per acre, based upon the cost of only part of the original project.

Unification of the Existing Canal System

In 1904, there were 110 canals, having an aggregate length of about 475 miles, taking water from the Uncompahgre for irrigation in the valley. It was thought they could be connected so as to serve adequately most of the project. Two of the largest canals were common carriers but the others were owned and operated by the farmers that they served. Since these farmers would benefit from the Gunnison water, it was thought they would immediately turn over their control to the Association in return for a credit allowance on their construction charges for the project.

Efforts of the Association to unify the canals failed after years of negotiation, and at its request the Government assumed the task of providing the distribution system. A comparison of the final costs paid for some of the canals by the Government and their appraised value, their original costs, or their value as determined by a Board of Arbitration is shown in the following table:

TABLE 1
COST OF CANALS

Canal	Evaluation*	Final Price Paid
Montrose and Delta...	(\$20,000 (a) (50,000 (b)	\$111,000
Loutsenhizer.....	8,000 (c)	15,000
Ironstone.....	(30,760 (d) (51,360 (e)	64,000
Garnet.....	9,600 (e)	18,179
Chipeta.....	8,000 (e)	12,600
Delta Chief.....	3,000 (e)	6,000

*(a) The assessed value; (b) Company capitalization; (c) Offered for sale before project undertaken; (d) Cost of construction; (e) Set by Board of Arbitration.

The responsibility for the excessive prices paid for the canals rests jointly with the Government and the stockholders in the various canal companies. The Government is accused of gross extravagance, mismanagement, and unbusinesslike conduct. The farmers and stockholders are accused of graft, misconduct, and disloyalty to their fellow farmers. Regardless of who is to blame,

the high prices paid for the canals have resulted in a greatly increased financial burden on the project farmers.

Construction of the Canal System

During the period of litigation for control of the existing canals on the project, new canals were constructed and the old ones were enlarged and extended to accommodate the increased flow of water which was to be diverted into the new systems. Due to delays and uncertainties in securing control of the old canal properties, a great part of the carrying system was not completed until several years after Gunnison water was first brought into the valley. As a result, water was not supplied to much land which otherwise would have contributed to the support of the project. The distribution system, now in use, is fairly satisfactory on the whole, but there is little doubt that many features were poorly planned, ill advised, or badly constructed. For these reasons they have contributed to the high costs of the project.

The distribution system provides for the diversion of Gunnison River water through the tunnel and the South Canal to supplement the flow of the Uncompahgre River. Eight canal systems distribute water to the farms. The East, Loutsenhizer, South, Selig, and Garnet systems serve the eastern part of the project. The Montrose and Delta, Ironstone, and West systems carry water to the farms on the west side of the river. With the exception of the South Canal system, that secures its water directly from the tunnel, all the canals take water from the Uncompahgre by means of diversion dams. The West Canal can secure water directly from the South Canal by means of a flume across the river. The Government has constructed and improved 45 miles of canals with a capacity greater than 300 second-feet; 127 miles with a capacity of 50 to 300 second-feet; and about 378 miles of ditches with a capacity less than 50 second-feet.

The distribution system depends on gravity flow and many ingenious adjustments to the irregular topography were made in the location and construction of the canals. Wherever possible and economical they follow contours, but elsewhere it was necessary to construct inclined chutes, vertical drops, flumes, siphons, and tunnels. Numerous cement structures were built to overcome the erosive force of water carried in canals which had been constructed through the deeply eroded hills or along the uneven, steep-sided

mesas.

Within a short time much of the concrete lining and other structures had to be repaired or replaced. The concrete had been badly damaged by:

1. Expansion and contraction cracks which developed in the floors and walls, due to the failure of the engineers to leave adequate joints in the concrete.
2. Bulging of the floor and caving of the walls which occurred where the concrete had been placed directly on shale that was highly impregnated with gypsum. This spongy material expands and contracts to a high degree with varying quantities of water.
3. Erosion and cracking which was serious in some parts of the canal where the rushing water set up violent vibrations in the concrete lining.
4. Alkali action which attacked the concrete, forming a soft mass that was easily removed by flowing water.
5. Cloudbursts and floods which washed out sections of the canals.

Evidently laboring under a delusion that the entire irrigable area would be settled promptly and that all the area would be cultivated successfully, the Government constructed many canals and lateral ditches that have never been justified. Possibly several hundred thousand dollars could have been saved if an adequate geographic and economic survey had been made before construction was undertaken.

Construction Costs

Soon after it was evident that the costs would be much higher than had been estimated, the water users began to clamor for the Government to charge off certain cost items. All the adjustment claims amounted to \$4,056,957, although there are a number of inseparable duplications which, if eliminated, would lower this total considerably. After many hearings, the Government finally cancelled \$1,258,323 from the cost of the project. The tabulated costs and credits were as follows:

Feature	Cost
Examination	\$ 96,542.00
Storage System Surveys	12,699.00
Carrier System	4,030,751.00
Lateral System	2,215,861.00
Drainage System Studies	3,940.00
Power System	274.00
Telephone System	6,788.00
Permanent Improvements	31,969.00
Irrigable Land Purchase	39,353.00

Total Construction Cost	\$6,438,177.00
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Operation and Maintenance During Construction	1,490,584.88
Interest and Penalties	1,191,274.59
Plant and Equipment on Hand	16,717.76
Miscellaneous Revenue	7,505.96

Total Project Cost	\$7,986,696.65
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	Credit
Charge-off, Act of May 25, 1926	1,258,322.88
Rental of Irrigation Water	1,191,274.59
Rental of Project Buildings	16,717.76
Miscellaneous Revenue	7,505.96

Total Reductions and Revenues	\$2,473,821.19
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Grand Total to be Repaid to the Reclamation Fund (January 1, 1930) . .	\$5,510,875.46
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The continued dissatisfaction of the water users over the water charges resulted in a new contract between the Association and the Government, on August 4, 1931. Under this contract the productive, irrigable area was set at 72,036.5 acres, and a new schedule of costs and charges was established as follows:

Seventy-two thousand and thirty-six and five-tenths acres of productive, irrigable land to be charged at a rate of fifty-two dollars per acre	\$3,745,898.00
Less cost reductions and accruals	1,221,312.87

Total net primary construction charges .	\$2,524,585.13
Net supplemental construction costs added	842,211.89

Total amount due the Reclamation Fund . .	\$3,366,797.02
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The remainder of the actual construction costs of the project will be paid out of the Reclamation Fund, or are considered as a charge against land which at present is rated unproductive. If and when such land is brought into a state of productivity, a charge of fifty-two dollars per acre will be levied against it, and the proceeds taken over by the Reclamation Fund. As it is very doubtful whether any considerable portion of the land now classified as unproductive will ever be reclaimed, it is generally conceded that the Government stands to lose about \$3,402,400 on the project.

III. SETTLEMENT OF THE PROJECT

Settlement of the project has been slow and unsatisfactory from the outset. Slow settlement, with resultant incomplete utilization of the land, has created various problems. Many homesteaders were attracted to the area with the completion of the Denver and Rio Grande Western Railroad in 1882. Most of the homesteads were secured under the Desert Land Act and the Pre-emption Laws, and it is estimated that approximately 100,000 acres in the valley had been patented by the time the Government undertook its reclamation project, with about 30,000 acres irrigated. During this early period of development, good water rights could be secured for about eight hundred dollars per second-foot, an amount sufficient to serve an eighty acre farm.

When the Government approved the project in 1904 there were 106,000 acres privately owned, 15,000 acres on which entries had been filed, and 19,000 acres of public land. Most of the public land was in the less desirable portions of the valley, and much of it was infertile, seeped, or hilly. Probably not more than 6,000 or 7,000 people have settled on the project since 1904, but no accurate records of population are available prior to 1918. Since 1918, the town population has increased from 6,950 to 7,400, and the farm population from 5,279 to 5,713.

Settlers from many sections and from many walks of life were attracted to the project. Many of them were poorly equipped, technically and financially, to undertake the difficult task of making a living from irrigation agriculture. Many had no earlier experience in any type of agriculture and still more had no training in the technique of irrigation. Without guidance or technical

aid, they expected to develop profitable farms out of the virgin soil.

The privately owned land was subdivided into small blocks and sold at exorbitant prices to newcomers. Misled as to the cost of water and misguided by exaggerated statements of newspapers and real estate men as to the profitableness of irrigation farming, most of the settlers purchased land at prices out of all keeping with its value. It is estimated by real estate men that practically all of the land which changed ownership in the earlier years of the project did so on a valuation four or five times its true value.

Only 15 per cent of the settlers were able to pay cash for their farms, and most of them immediately mortgaged their farms to secure the money needed to prepare the land for agriculture. Regardless of the original purchase price, many settlers soon found themselves burdened by indebtedness so large that they were forced into bankruptcy. Many, having lost all their money, moved away from the project. Others, who had lost their original farms, obtained land elsewhere on the project. The original landowners profited under the system, many of them not only once but several times, as the same parcel of land was sold, abandoned, and resold.

The plight of many early settlers was aggravated by the inability of the Government to supply them with irrigation water for several years after they had established residence on their land. Many homeseekers who desired good land moved onto the project soon after 1904, because it was feared that all the better land would soon be taken. Many of these settlers were unable to start farming until 1911, as their farms did not have a water right and the Government was unable to deliver water from the tunnel until late in 1910.

The mortgage indebtedness of the project land rose higher and higher as time went on. In 1915, 89,367 acres carried a mortgage indebtedness of \$3,035,370, or an average of \$1,620 per encumbered farm. Chattel mortgages on equipment and livestock were at least \$968,000. In 1925, although the assessed value per farm was only \$2,646, the mortgage indebtedness was \$3,197. Interest rates on loans have been extremely high. The published rates have averaged between 8 and 12 per cent on real estate and between 10 and 15 per cent on chattel loans. However, commissions and renewal fees on the normal three year loan make the actual interest rates

much higher. Taxes have increased greatly since the project was started. The total levy in 1913 was only 15.35 mills, but this increased to 27.65 mills in 1923 and to 36.53 mills in 1933. Thus, the standing overhead charge per acre on mortgaged land amounts to:

Taxes	\$ 2.37 per acre
Interest on land mortgage	5.16
Interest on chattel mortgage	3.00
Project construction charge	1.75
Operation and maintenance charge	1.40

Total overhead charge \$14.68

The number of farm units operated by tenants has always been large in comparison with the number operated by owners, and this explains many of the poor agricultural practices carried on throughout the valley. In recent years nearly 50 per cent of the farms, comprising about 52 per cent of the acreage of the project, have been operated by tenants. In addition, a considerable number of farms are being operated by hired managers, more or less under the direction of the owners. The average period of occupancy of a given farm unit by a tenant is only about three years and only a small per cent of the tenants appear to be making any attempt to secure farms of their own.

The rapid change in farm ownership is also an important factor retarding development of the project. Many of the changes resulted from a ruling by the Government that no individual could own a farm-unit and a non-subscribed farm on the project at the same time, nor could anyone own more than 160 acres of land unless all project charges were paid on one of the units or for the excess over 160 acres. Three years were allowed landholders to dispose of land secured through foreclosure or inheritance, in excess of the legal limits. However, many farmers, not wishing to sell, have divided excess land into legal units and deeded the surplus units to members of their families. The Government has found no way to compel a man to dispose of his excess holdings when there are no buyers for the land. As a result, certain individuals control large holdings; one estate, along with the land held by the administrator, comprises more than one-thirtieth of the project. However, large landowners are entitled to only one vote at meetings of the Water Users Association.

Approximately 40 per cent of the irrigable land is under the control of non-resident land owners, land companies, or loan agencies. It is impossible to determine what percentage of this land was acquired with a view of capitalizing on the increased

land values anticipated from the development of the project by the Government. However, the large amount of land held in blocks of more than 160 acres reflects the speculative efforts of many non-residents. Some land held under absentee ownership undoubtedly was secured in the process of mortgage foreclosure and not with a primary desire to profit from control of the land. The large acreage held under absentee ownership has been detrimental to the development of the project. Much of this land is not being farmed and the remainder is only partially utilized by tenant farmers. There is a strong possibility that most of this land, which is not contributing a fair share to the maintenance of the project, will eventually revert to the Government.

IV. THE OPERATION AND MAINTENANCE OF THE PROJECT

The systems are all operated on a simple gravity-flow basis, and with the exception of a siphon, tunnel, or flume here and there, the open canals follow contour lines. For this reason certain of the canals, such as the Selig and East, run for considerable distances through waste land before reaching the scattered areas of irrigable and irrigated land.

Under the original contract between the Government and the Water Users Association, the operation, maintenance, and control of the project were to be assumed by the Association on the completion of the project. Due to the length of time involved in completing the primary construction work and to the weakness of the Association, the transfer of these obligations was delayed until 1932. The effect of the transfer has been to stimulate the Association to greater efforts and responsibility in the project.

The cost of operating the distribution system is so high that the farmers have had great difficulty in meeting their operation assessments. The average annual cost of operation has been \$37,048, and during fourteen of the twenty-two years examined there was a deficit in the operation and maintenance payments. A summary of operation costs between 1924 and 1930 follows:

TABLE 2

SUMMARY OF OPERATION COSTS BY CANAL SYSTEMS
1924-1930*

System	Total Operation Cost	Per Acre Irrigable	Irrigated	Per System Mile	Per Acre Ft. Carried	Per Water User
Gunnison Tunnel..	\$3,312	....	....	.....	....	.....
South Carriage...	2,266	....	....	.....	....	.....
Montrose-Delta...	9,290	\$.391	\$.455	\$104.50	\$.074	\$16.02
Ironstone.....	6,009	.322	.391	57.06	.063	16.70
Selig.....	4,406	.575	.929	56.20	.122	37.02
East.....	3,677	.579	.798	54.32	.103	23.71
South Lateral....	2,295	.364	.497	43.80	.060	15.97
West.....	2,541	.476	.564	70.00	.066	21.35
Loutsenhizer.....	2,122	.371	.455	64.64	.074	15.76
Garnet.....	1,240	.609	.773	70.85	.095	12.66

*Reclamation Bureau, "History of the Uncompahgre Project," Denver Office MSS.

The Water Supply

The project has been handicapped from the beginning by lack of a sufficient and reliable water supply for the lands being irrigated. Government engineers in 1914 assumed that the irrigated area would total 125,000 acres and that each acre would need three acre feet of water annually for normal crop production. On this assumption they showed that:

The normal water supply without storage would be ample for six out of thirteen years, with insignificant shortages for six years and a very serious shortage for one year in thirteen years, when the shortage would be nearly 47 per cent of the required supply for the assumed acreage. The losses even in such a year with the present [1914] cultivated acreage of approximately 55,000 acres would have been serious and for the full acreage of 125,000 acres enormous.¹

Never in the history of the project has the irrigated area or the duty of the water serving these lands even closely approximated the early estimates. The estimated irrigable acreage has been decreased to 72,036 acres (Class 1 land), and the land actually irrigated has averaged only about 60,000 acres in recent years. And at the same time, the duty of water on the project has averaged 5.46 acre feet, which is 1.46 acre feet more per acre than

¹Reclamation Record, March, 1917, p. 130.

had been estimated. Thus, while the irrigable area has been decreased 42 per cent, the amount of water required per acre of irrigated land has increased 82 per cent. It is apparent that shortage of water remains a serious problem, in spite of the fact that the irrigated area is not now and never can be as large as formerly estimated. With the entire estimated irrigable area under cultivation, the water shortage would be acute.

The shortage of water always has been a source of friction between the farmers and the Government. In many years, it is necessary to apportion the available water between the different canal districts. Water is withheld from one or more canals for several days, in order that other canals can be operated under a full head of water. Without a full head, farmers have great difficulty in satisfactorily irrigating their crops.

The insufficient and irregular water supply for the project is due largely to the erratic regimen of the two rivers. The flow of the streams, during the irrigation season from April to November inclusive, varies greatly from year to year. For example, in 1920 the Gunnison River furnished 1,647,677 acre feet of water, but during the previous season it carried only 976,250 acre feet. The Uncompahgre River had a flow of 289,128 acre feet during the 1921 irrigation season, but its runoff in 1919 was only 148,245 acre feet. This unsatisfactory regimen made it necessary to rotate water in the canals during seven of the eleven years examined.

The Taylor Park Reservoir, constructed by the Government as a project under the National Industrial Recovery Act, is expected to correct this unsatisfactory water supply situation. It is estimated that it will have a capacity of 105,000 acre feet and that it will supply a full head of water for all the project canals for a period of fifty days. The cost of the dam and appurtenant works, estimated at two million dollars, will be repaid by the Water Users' Association in forty annual installments. The cost of this work will amount to approximately \$27.77 per irrigable acre. The reservoir will not eliminate temporary and local water shortages because there are many factors other than stream flow that make it necessary to shut off water from certain tracts and at times from the entire distribution system.

The irrigation season extends from the middle of April to the middle of October, and it is during this time, of course, that operation work is at its peak. Only enough water is carried in

the canals out of season to supply domestic water and stock water for the farms. The following table shows the average diversion and use of water between 1924 and 1930. Prior to 1923, water had been delivered to the farmers on a continuous-flow basis, and certain results of that system of delivery are shown for comparison.

TABLE 3
WATER DIVERSIONS

	Inflow to Canals	Diverted to Laterals	Delivered to Farms	Delivered to Farms Under Continuous- Flow System
Acre-feet.....	472,684	330,645	293,510	....
Acre-feet per acre irri- gated.....	7.83	5.46	4.85	6.11
Percentage of inflow.....	100	70	62	84

More water is lost through seepage and evaporation from the laterals than from the main canals. These losses¹ vary greatly between different canal systems. The large amount lost is due to the low relative humidity of the air, to the open and porous ground through which the inclined canals pass and to the great length of uncovered canals and laterals. Other things being equal, the largest loss from seepage occurs in canals constructed through sand, loam, and gravel, and the smallest amount in canals whose beds have been constructed in adobe, shale, and shale-loam. Thus the canals on the west side of the valley have a tendency to lose more water from seepage than do those on the east side, because the west side soils are more porous and open than the clay soils east of the river.

Under the continuous-flow delivery system used prior to 1923, the average annual waste of water was only 10 per cent and the annual loss only 7 per cent of the total inflow into the canals,

¹The term "waste" is loosely used to designate water which is not delivered to farms but is turned out of the canals and laterals at the end of the distribution system. The term "loss" is applied to water which escapes from the canals and laterals through seepage and evaporation.

as compared with a waste of 12.2 per cent and a loss of 25.7 per cent under the acre-foot-on-demand system now used. This would seem to indicate that the new method has been less efficient than the old one. However, from the standpoint of the duty of the water, which has changed from 6.10 acre feet per acre under the continuous-flow system to 4.85 acre feet per acre under the new method, it is obvious that no decrease in efficiency has taken place.

Maintenance of the Project

Maintenance includes the repair, replacement, or improvement of any feature that contributes to the welfare of the project, and is divided between normal, expected, routine work, and irregular, unforeseen repairs made necessary by damage from cloudbursts, floods, landslides, and alkali action. The cost of the first type of maintenance is more or less uniform from year to year, but as a result of the latter type, the total costs in any one year may be much greater than for a normal year. Minor repairs, such as mending small breaks in ditches, removing weeds from outlets, and mending flumes, are usually made by the ditchriders. Replacements and improvements of structures are generally done by the engineering force and operation crews during the winter.

The irrigation system now is and always will be rather expensive to maintain because of the widespread development of seepage and alkali. Seeped and alkali land is common to most arid, irrigated regions where the natural underground drainage is unable to carry off the excess water applied to the soils during irrigation. This is especially true in the Uncompahgre Valley (Fig. 4), because the sub-stratum of Cretaceous shale is impervious. The excess water does not find a satisfactory outlet through the shale and eventually raises the ground water level to the surface.

Seeped land always contains large quantities of alkali. The highly fractured and shattered shales contain much soluble gypsum and other alkaline salts that are dissolved out by percolating ground water. When this ground water finally reaches the surface and is evaporated, the dissolved salts are concentrated in the top soil.

Alkali causes the deterioration of all structural materials with which it comes in contact. Disintegration of concrete becomes serious within a few years after it has been laid. The damage to concrete work caused by alkali is both direct and indirect. In the



Fig. 4.--Distribution of seeped and alkali land.

first place, there is a direct chemical reaction between the various sulphates and the concrete. In the second place, an indirect damage results when the alkali salts are leached out of the shale foundations of concrete lined canals and tunnels, causing the shale to shrink away from the concrete. Then the pressure of the water in the canal causes breaks in the unsupported canal wall. On the other hand, the unleached shale has a great expansion force when wet, which causes cracking of the concrete walls where they are constructed at too steep an angle. The expansion and swelling of alkali shale at the bottom of the large, concrete-lined canals cause the floor to buckle. Concrete failures and deterioration, resulting from alkali action, have been decreasing in recent years due to improved construction technique. Alkali action is not confined to concrete, but affects metal and timber as well. Coating all exposed surfaces with a tar compound has greatly increased the life of structural materials, but has not solved all the problems.

Drainage is badly needed on a large part of the project to prevent further damage to the land and to engineering structures from seepage and alkali. In the early stages of development, seepage can be corrected by drainage and the reclaimed soil is but slightly affected by the experience. However, in the later stages, the concentration of alkali is so great that drainage does not materially improve the land. The excess water is removed and new alkali accumulation is prevented but the soil has been so badly impregnated that crop production is almost impossible. During the earlier years of the project, about one hundred miles of cement and tile drains were laid, which were effective for a short time. However, within a few years alkali had so badly decomposed the tiles that they were no longer able to carry off the excess water. This expensive type of drainage was then abandoned and the open ditch type has since been used. It has been estimated that at least 135 miles of mainline, open drains, and an unestimated mileage of feeders will be needed to drain the project.

The cost of draining the land has been high, averaging between \$25 and \$75 per acre. As a result, only a few farmers have constructed the ditches necessary to protect their lands adequately from seepage. Most of the farmers felt that the cost of drainage should be carried by the Government, since in most cases they had not been informed of the possible need for drainage when they settled on their farms. They argue that since the cost of the

project per acre had been much higher than anticipated, and since the net returns from farming were lower than expected, they could not assume the burden of drainage. The Bureau of Reclamation evidently felt that the farmers had been too tardy in fulfilling their obligations with respect to the costs of project construction, operation, and maintenance to justify assumption by the Government of this added expense. Both parties, the farmers and the Bureau, appear to have been short-sighted in the matter. If the farmers did not undertake drainage, the chances of making a living from their farms would be diminished greatly. If the Government did not construct the drainage system, the possibilities of project-cost repayment were small. Finally, a contract was entered into in 1934 by the Water Users' Association and the Bureau of Reclamation, whereby future drainage will be undertaken by the Association. Under this contract, the Association will construct the necessary drainage system before the end of 1942. In order that the present financial burden of the farmers may not be increased by this work, the Government has arranged to have all these costs deferred until after the construction costs have been retired in 1962. The farmers entered into this contract with enthusiasm because they believe the Government will eventually assume the cost of drainage.

Water Charges and Accruals

Prior to 1923, irrigation water was delivered to the farms on a continuous-flow basis. This method of delivery did not mean that the flow of water in the farmer's ditch was continuous or that the use of the water was continuous, but that the right to secure a given flow or head of water in the ditch was continuous. The headgate was set at a given level and the farmer would turn the water on or off, using as much or as little of the fixed-flow as he desired. There can be no doubt that the continuous-flow method was unadapted to the best interests of the project. It led to careless and inefficient use of water and materially decreased the potential irrigable acreage. Theoretically, water would be turned off at a headgate when no irrigating was being done. In reality, farmers too frequently failed to turn off the water, permitting it to flow out over waste, pasture, or fallow land. This increased the amount of water used and resulted in an enlargement of seepage areas.

The acre-foot-on-demand method of water delivery,

introduced in 1923, entitles the farmer to a fixed amount of water, which can be secured when desired, subject to such regulations as may be necessary for the good of the entire project. The water charges are based on the estimated costs of operation and maintenance of the project, and any surplus or deficit is considered in determining the charges for the following year. After a long period of trial and error, a rate was established which met with the approval of the farmers. Since the very porous soils on the west side of the valley require much water for growing crops, the west-side farmers demanded a charge based on a minimum acre-foot scale adjusted to soil conditions. The farmers on the east side of the river, citing the lower productivity and also the lower water requirements of their soils, demanded a lower minimum scale. Since 1933 the water rates have been thirty-five cents per acre-foot, with a minimum charge of \$1.75 per acre for the west-side land and a minimum charge of \$1.40 per acre for the east-side land. The same rate applies for all additional water up to seven acre-feet, but for water in excess of that amount the charge was twenty-five cents per acre-foot.

The average annual deficit on operation and maintenance has been \$11,389, with deficits occurring in twelve of the twenty-two years examined. The deficits have been decreasing since 1919, and in seven years a small average gain has been made. The original contract between the water users and the Government stated that no water was to be delivered to delinquent accounts until such delinquencies had been corrected. As the number of delinquencies increased from year to year, it became apparent that some farmers were totally unable each year to meet their water charges. If the provisions of the contract had been enforced, it is probable that many farmers would have been unable to secure water and that much land would have been abandoned. This would have left the Government with a great surplus of water, a continuing high cost of operation and maintenance, and only a few farmers paying. Partly as a rehabilitation measure and partly as an insurance for the large investment involved, the Bureau at frequent intervals has made adjustments to permit water users to continue their farming until such time as they can pay their water charges.

The operation and maintenance costs under Association management were materially lower than the costs under Government management. During the first year of management by the Association,

1932, a saving of \$27,480.39 over the previous five year average was recorded. During 1933 the saving in the cost of operation and maintenance totalled \$35,058. This saving was made in spite of the poor state of maintenance of the project when turned over by the Government and in spite of certain extra costs assumed by the Association that were not incurred by the Government.

V. AGRICULTURAL DEVELOPMENT ON THE PROJECT

The purpose of the National Reclamation Act, to create prosperous farms on which citizens could satisfactorily support their families, has not been fulfilled on the Uncompahgre Project. Although excellent crops can be grown, the high production and marketing costs result in low net returns. Only in the most favorable years, when crop yields are heavy and prices are high, are the farmers successful. In most years the economic welfare of the people has been at a low level. In spite of the sincere efforts of many farmers the project indebtedness has increased. In spite of excellent crops in many years, the farmers have not prospered and a spirit of pessimism pervades the project.

Total Crop Acreage

The expectation of the Reclamation Bureau that all of the irrigable land would be promptly settled and cultivated has not been realized. The practicability of the venture was based on an estimated irrigable area of 120,000 acres, yet less than 51 per cent of that area has been irrigated. It has been estimated that approximately 30,000 acres were being farmed at the time the Government took over the project in 1904. The cropped acreage had increased only 30,382 acres up to 1930. Seven crops occupy approximately 92 per cent of the cropped area and produce nearly 99 per cent of the total gross value of all crops grown on the project. The seven principal crops in the order of their importance are: alfalfa, wheat, potatoes, oats, sugar beets, corn, and onions. Pasture land, which is largely in native grass and is not under cultivation has been excluded from this analysis.

Gross Value of Crops

The average annual gross value of all crops for the sixteen

year period between 1914 and 1930 was \$2,279,164. Between 1917 and 1921, when the project was enjoying its greatest prosperity, the annual crop value exceeded three million dollars. Since that period, with the exception of a prosperous year in 1925, the annual crop value has averaged only a little over two million dollars.

Eight crops return 93 per cent of the total gross value of all crops on the project. Although these crops vary in their relative importance from year to year, they are ranked in the following order: potatoes, alfalfa, onions, wheat, sugar beets, apples, oats, and corn (Table 4).

TABLE 4
CROP YIELD REPORT FOR 1927*

	Acreage	Per Cent of Total Acreage	Average Yield Per Acre	Unit Value	Value Per Acre
Alfalfa.....	23,078	42.2	2.2 t.	\$ 6.24	\$ 13.91
Alfalfa seed..	211	.3	.3 bu.	17.27	5.72
Wheat.....	9,963	17.6	27.4 bus.	.92	25.17
Potatoes.....	7,288	12.9	84.5 bus.	.38	31.83
Corn.....	3,440	6.1	30.9 bus.	.71	21.39
Beets.....	3,139	5.4	10.5 t.	6.50	28.14
Oats.....	2,823	4.9	33.4 bus.	.49	16.48
Apples.....	1,333	2.4	3,466.0 lb.	.42	100.26
Barley.....	925	1.6	31.2 bus.	.74	22.89
Hay and seed..	663	1.1	.....	.....	17.58
Garden.....	407	.8	.....	.....	74.46
Beans.....	205	.3	15.3 bus.	2.19	33.58
Small fruit...	73	....	.....	.....	176.46
Miscellaneous.	425	.8	.....	.....	77.13
Total.....	56,564	100.0	.....	.....	\$ 29.84

*Reclamation Bureau, op. cit., XIX (1927), 70.

Crops in Relation to Climate and Weather

The climate of the Uncompahgre Valley, although in general satisfactory for the growing of irrigated, general-farm crops, does not possess any unusual advantages over that of most of the cropped areas of western United States. Sixty-three and eight-tenths per cent of the farms had poor or only fair crops and 36.2 per cent had good or excellent crops during the twelve years ending in 1929.

The growing season is too short and too variable for the best development of crops; its length varies from 110 to 214 frost-free days, with an average length of 165 days. However, the high percentage of sunlight permits many crops to mature which perhaps could not mature if more cloudy weather prevailed. The average date of the last killing frost in spring is May 6 and the average date of the first killing frost of autumn is October 10. Crops were injured by either late frosts in spring or by early frosts in autumn in nine of the seventeen years ending in 1929. Frost damage to crops seldom occurs over the entire project and seldom are all crops affected at the same time. Although frost damage may occur in any part of the valley, the lower inter-mesa flatlands and river bottoms are affected most often.

The mean monthly temperatures range from 23.3°F. in January to 71.6°F. in July, and the monthly departures from the normal are never great (Table 5). Marked and sudden temperature changes take place, and it is not uncommon to have a nocturnal temperature from 25 to 30 degrees lower than the diurnal temperatures.

TABLE 5

TEMPERATURE DATA FOR MONTROSE IN DEGREES
FAHRENHEIT (1913-1930)*

Month	Mean Monthly	Average Monthly Maximum	Highest 24-Hour Average	Average Monthly Minimum	Lowest 24-Hour Average	Departures from Normal	
						Above	Below
Jan.	23.3	48.7	57	- 5.5	-25	4.6	4.6
Feb.	31.2	56.1	64	3.9	-14	3.1	2.7
Mar.	38.1	67.9	74	10.4	- 3	3.6	2.6
Apr.	47.5	76.3	82	20.0	9	2.6	3.2
May	57.2	85.3	90	29.7	22	2.0	2.8
June	66.5	92.5	98	36.1	22	1.7	1.9
July	71.6	94.2	102	47.6	41	1.5	1.6
Aug.	68.9	90.9	96	44.2	40	1.7	1.1
Sept.	61.0	87.1	92	32.3	28	2.2	1.9
Oct.	49.0	77.9	83	21.3	9	2.3	2.1
Nov.	37.3	66.0	74	10.8	- 3	3.3	3.2
Dec.	25.9	54.7	63	- 4.0	21	4.3	2.5

*Compiled from the records of the Project Engineer.

The annual rainfall of only 10.15 inches is insufficient for crops, even though dry-farming methods are employed. Rainfall is so slight (Table 6) that it rarely interferes with farm work. Most of the precipitation occurs in convectional thunderstorms,

and the entire rainfall for a month may fall in a single shower. These showers often attain cloudburst proportions and frequently cause considerable damage.

TABLE 6
PRECIPITATION AT MONTROSE IN INCHES (1913-1930)*

Month	Mean Monthly Average	Departures from Normal		Greatest Rainfall in Any Twenty-four Hours	
		Above	Below	Monthly Average	Absolute Maximum
January....	.58	.36	.31	.25	.43
February...	.42	.23	.24	.18	.38
March.....	.79	.63	.33	.31	.69
April.....	.96	.42	.46	.38	.80
May.....	1.25	.66	.57	.57	1.07
June.....	.53	.63	.31	.31	.83
July.....	.93	.48	.35	.38	1.00
August.....	1.28	.65	.48	.47	.88
September..	1.04	.68	.47	.41	.92
October....	.99	.66	.53	.40	.84
November...	.64	.53	.42	.32	.88
December...	.74	.50	.34	.31	.84

*Compiled from the records of the Project Engineer.

In one out of three years the spring rains are inadequate to carry young plants through their initial growing period. Crops are injured by a too wet spring in about one out of every four years. The harvest season of August, September, and October is usually favorable for farm operations.

Crops in Relation to Seepage and Alkali

Seepage and alkali, which is present on almost every farm, directly affect the quality and quantity of crop yields. The large area of abandoned farmland; the large, barren patches within the cropped fields; and the stunted, sickly appearance of the plants in many fields are ever-present proof that seepage and alkali are reducing agricultural yields.

The farmers are largely responsible for the development and spread of the seepage and alkali areas, although the condition has been aggravated, and in many places started, by seepage from the canals and ditches located on sandy mesas and in slopes of the shale hills. The farmers have used too much water in irrigating

their crops. As a result, the duty of water on this project has been extremely low, an average of 5.38 acre feet of water being used per acre irrigated.

The widespread distribution of seepage and alkali is working a serious hardship on the farmers. Although the total financial loss cannot be determined, there is no doubt that this condition has been a major cause for the unsatisfactory progress of the farmers. The financial burden imposed upon them by the development and spread of seepage and alkali manifests itself in a number of ways:

1. There is a direct loss resulting from reduced yields of crops planted in alkaline soils. This may vary from only a small percentage of the possible yields to a complete loss.
2. The failure of the Association and the Bureau to exclude the small tracts of seepage and alkali land from the irrigable land classification forces many farmers to pay full project construction costs and water charges on land that is unfit for cultivation. This increases the overhead for the farm and decreases the chance of success for its owner.
3. Many farms have been abandoned as a result of excessive accumulation of seepage and alkali. The proportion of the construction, operation, and maintenance charges that normally would be carried by that land if it were productive must eventually be repaid by the remaining productive lands.
4. A less tangible, but nevertheless important result of alkali and seepage accumulation is observed in the attitude of those farmers whose farms are slowly being ruined by this condition. It is apparent that such farmers adopt a pessimistic outlook and fall into slovenly, careless, and unscientific agricultural practices. The productive land on their farms is not made to produce normal yields and they soon become hopelessly in debt. At the same time, careless practices tend to increase the seepage and alkali evil over the entire project.

Crops in Relation to Soils

The acreage devoted to each type of crop, as well as the yields per acre, show a marked relationship to the soil conditions (Fig. 5). The more fertile and more valuable soils, which were derived from transported materials, lie to the west of the Uncompahgre River. They are deep, durable, and easily workable, containing more silt and sand than the soils east of the river. The latter soils are mostly clay, adobe, or clay-loam, and they tend to be so heavy and cold that special methods are required in their cultivation. About 95 per cent of the irrigable area is occupied by seven major types of soils. Although individual farmers may exercise good judgment in the selection of crop combinations

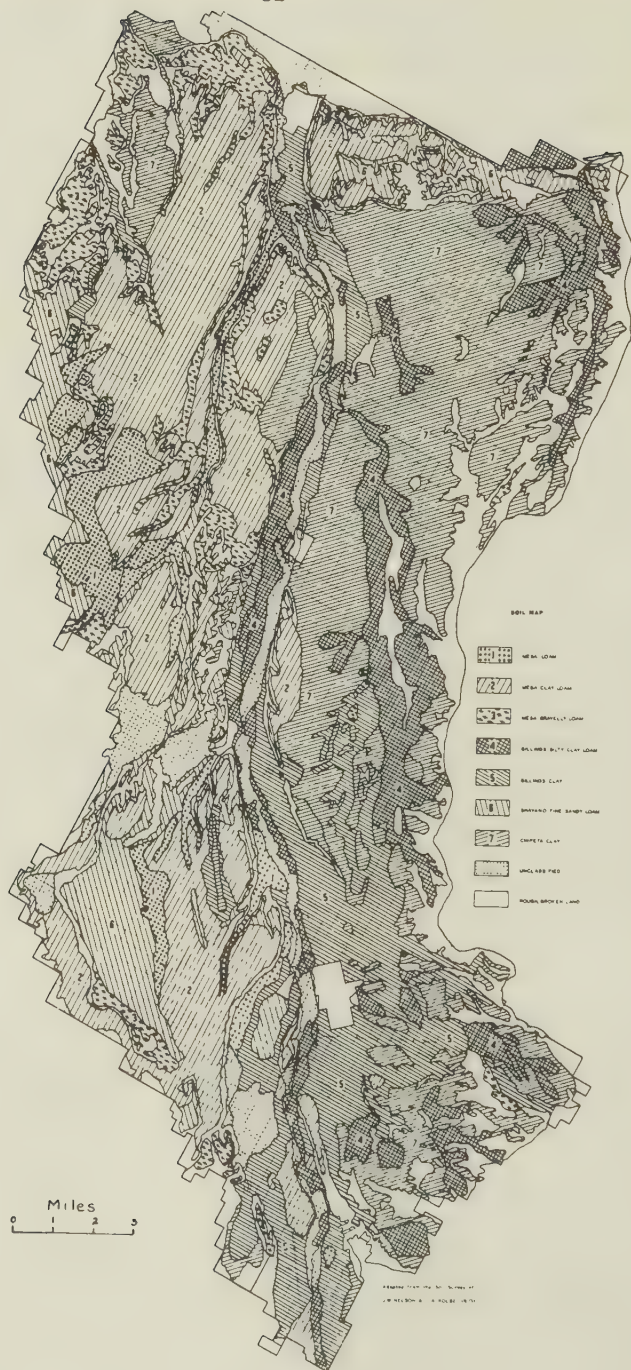


Fig. 5.--Distribution of major soils on the project.

adjusted to their particular soil conditions, all crops common to the project are grown on all types of soils.

Crop Rotation Systems

There is no uniformity in the systems of crop rotation practiced. In fact, there are about as many rotation systems, if with license they may be called systems, as there are farmers. On many farms there is no apparent attempt made to rotate crops on a scientific basis. The average farmer realizes the advantages of growing alfalfa on land that has been planted to corn, wheat, oats, beets, or potatoes over a period of years, and so, at varying intervals, he will grow alfalfa for a few years. Beyond that, he grows whatever crop he thinks will have a large demand and a high price. Thus, a vicious type of crop speculation has developed that has retarded the adoption of any fixed and scientific rotation system. Those farmers who do practice a definite crop rotation system almost invariably have a better economic standing than those who do not. Over a period of years the net returns from a planned rotation system are higher than where no rotation is practiced.

Crop Production Costs and Revenues

The type of agriculture practiced by the average farmer does not return a net profit in most years. Not all farmers lose money; some of them make a living and meet all charges when due. The general lack of success is proved by the following facts:

1. Crop production costs and revenue studies show annual losses ranging from three to ten dollars an acre.
2. The mortgage indebtedness of the farms is so high that it is difficult or impossible to secure further loans.
3. Many farmers have moved away from the project after expending their capital and labor on unsuccessful farms.
4. Land values have declined at a relatively rapid rate.
5. Much land that was formerly productive has been ruined by seepage and alkali.

A Comparison of the Agriculture on Different Sized Farms

Three groups of forty farms each were taken at random from the Individual Farm Studies¹ to determine representative conditions

¹Based upon the Water Users Census Reports for 1927, in the office of the Project Engineer.

on small, medium, and large sized farms on the project. The small farms, which average 33 acres in size, have 68 per cent of their land in crop; the medium sized farms average 74 acres and have 64 per cent of their land cropped; and the large sized farms average 139 acres of which 48 per cent is in crops (Table 7). The study supplied the following conclusions:

1. There is no conspicuous difference in farming on the different sized farms. In all three groups alfalfa, wheat, potatoes, beets, and corn are the dominant crops. However, there is some variation in the percentage of land devoted to certain crops. There is a tendency for fewer but larger fields on the larger farms.
2. Crop yields per acre are approximately the same regardless of the size of the farms. Extensive farming rather than intensive farming is more characteristic of the project.
3. There is only a negligible difference in the total gross crop value per acre in spite of variations in the value per acre for the different crops and in the percentage of land in crops for the three farm groups.
4. The total value of crops, subsistence crops excluded, per farm is \$567 for the small, \$1,080 for the medium, and \$1,667 for the large sized farms. Thus the crop-rate ratio per farm is in inverse ratio to the size of the farms.
5. The small farms have a higher per acre tax rate on both their irrigable and cropped acreage than do the larger units, but, on the other hand, the small percentage of the irrigable land that is tilled on the large farms makes the cost of the irrigating water an excessive burden on the cropped land.

Under present agricultural practices, the medium sized farms appear to be most successful. Farms having approximately eighty acres, with about 70 per cent of their total area in crops, seem to reflect greater prosperity and enterprise than do either the smaller or the larger units. The medium sized farms are taxed more fairly and afford opportunity greater for successful dairying.

VI. LIVESTOCK RANCHING

Livestock ranching was the outstanding activity of early settlers in the Uncompahgre Valley. Prior to the inauguration of relatively intensive agriculture, other activities were subordinate to the cattle industry. Agriculture of that time was adapted primarily to providing fattening food for market stock or winter forage for breed stock. Large fields of alfalfa, wheat, oats, and similar crops were grown wherever irrigation water could be secured. Tall grass covered the low river bottom and short, bunch

TABLE 7

CROP STATISTICS ON FARMS--THE RELATION OF CROPS ON FARMS OF BELOW
50 ACRES, 51 TO 100 ACRES, AND OVER 100 ACRES

Farms Having			Less Than 50 Acres	Between 51 and 100 Acres	Over 100 Acres					
Crop	Per Cent of Cropped Area		Yield Per Acre	Unit Value	Value Per Acre					
	Size of Farms		Size of Farms	Size of Farms	Size of Farms					
	Below 50	51 to 100	Over 100	Below 50	51 to 100	Over 100				
	42.9	48.2	39.1	2.24 t.	\$6.82	\$6.20	\$6.47	\$ 15.27	\$12.53	\$12.55
	16.4	16.5	22.0	24.4 bus.	.94	1.09	.94	22.97	26.36	23.97
	14.8	10.6	12.2	35.0 bus.	.69	.68	.77	24.26	20.06	23.27
	8.1	7.8	7.1	6.07 t.	6.50	6.44	6.50	39.46	43.70	37.42
	9.2	6.9	6.5	28.6 bus.	.73	.73	.89	20.88	26.29	27.40
	2.7	5.2	7.7	29.2 bus.	.60	.54	.52	17.67	24.24	14.01
	2.3	1.8	4.4	167.3 bus.	.70	.59	.69	117.90	83.54	95.25
	2.3	2.2	....	.....	.....	.....	.....	94.20	40.28	.....

Number of farms analyzed.....	40	40	40
Average size of farms in acres...	32.9	74.2	139.0
Average cropped area.....	22.2	47.5	66.7
Per cent of farms in crops.....	67.5	64.0	48.0
(pasture excluded)			
Crop value per farm.....	\$567.55	\$1,080.83	\$1,666.95
Crop value per irrigated acre....	25.57	22.75	25.01

grass was thick on the terraces and mesas. Large ranch houses, with their barns, corrals, and shelters, bespoke the prosperity that prevailed in the Valley.

The Uncompahgre region was admirably suited to the livestock industry. The surrounding mountains provided abundant summer pasturage, and the project farms could supply forage and pasture for winter. The winters were so mild and free from snow that cattle could graze on the open range; expensive shelters were not needed. In summer they escaped the high temperatures of the valley, for they were then grazed in the uplands. For these reasons and others, the number of livestock increased rapidly. Although no accurate records are available for this early period, it is probable that at least twenty-five thousand cattle were controlled by the ranchers of the valley.

Large-scale cattle ranching was supposed to be detrimental to the best interests of the project, the purpose of which was to create many small, self-sufficient farms. Intensification of farming failed to materialize on the scale anticipated by the Government. The Bureau of Reclamation, it is alleged, thereupon induced many farmers to engage in small-scale cattle ranching along with their farming, and obstacles were placed in the path of large ranchers. Owing to lack of experience and to inability to care for the small herds on the range, this venture was not successful.

The Forest Service, it is claimed, opened large tracts of the range to sheep when the income from cattle decreased. Sheepmen from Utah were eager to secure grazing permits and took this opportunity to expand their industry. It is alleged that they secured the co-operation of farmers in or near the Uncompahgre Valley to obtain grazing permits on National Forest land formerly utilized by local cattlemen.

The passage of the Stock Raising Homestead Act of 1916 doomed the remaining large-scale cattle ranches on the project, as nearly all open range between the project and the Forest Reserves was entered upon by homesteaders. A rapid decrease in the number of beef cattle associated with the project followed immediately.

The Sheep Industry

The sheep industry, which was in part responsible for the decline of the beef cattle industry, has not proved of great economic value to the project. The number of sheep increased for a

few years after the decline of the cattle industry, but since 1917 there has been a noticeable decrease in numbers. The Stock Raising Homestead Act of 1916 was fundamentally unsound, and in this region most homesteaders after securing title to land, found it advisable to dispose of their holdings to sheep men.

Few sheep are kept on the project for more than a few months each year. During the summer they are grazed on the mountain pastures, and in winter most of them are sent into Utah to the home ranches or are wintered on pasture lands in the foothills valleys around the project. Only in early spring and late fall would a visitor have any realization of the number of sheep associated with the project.

The Dairy Industry

"The expansion and intensification of dairy farming offers the greatest possibility of salvation for this project." Essentially this same statement has been made by practically every agricultural expert who has made a study of the valley. Those farmers who have developed dairy-farming on an intensive scale give proof of the accuracy of this statement. The dairy farms are almost invariably on a sound economic basis. Their buildings, fences, fields, and ditches are evidence of the advantages to be gained from this activity. Their appearance of efficiency and well-being stands out in contrast to the appearance of the average general-farm.

The valley, with a climate so temperate that cattle can graze in the fields throughout the year, is well suited for rearing dairy cattle. Fattening food is supplied in abundance on the farms. The large acreage in alfalfa assures a plentiful supply of hay, and alfalfa stubble makes excellent pasturage. The amount of corn planted is increasing yearly, and grain and fodder are relatively cheap. There is a large demand for dairy products in Montrose and Delta, where butter and cheese are manufactured and shipped.

The many benefits accruing from dairy-farming are fully realized by leading farmers and agricultural agents on the project and for years an active campaign has been waged to increase interest in it. In spite of all efforts, the number of dairy cattle has increased but slightly since 1922. In 1929, there were only 4,997 head of dairy cattle as compared with 4,139 head in 1922.

The direct benefits resulting from dairy-farming are as

follows:

1. A more rigid and scientific crop rotation system is introduced. A greater variety of crops are planted, some to provide feed for the cattle and some to provide a cash income. Crop speculation is reduced. The rotation of crops, pasture, and fallow land results in less soil impoverishment.
2. An intensification of farming is produced. The cropped area is reduced to provide more pasture land and the farmer tends to devote more care and effort to the crops on the reduced area. It was found that the cost of producing crops on the dairy-farms were higher than on the general-farms, but as a result of the greatly increased yields, the net income per acre was much higher.
3. The fertility and productivity of the land is built up by increased use of fertilizers. The dairy-farms have a large supply of manure, and use more beet-pulp and commercial fertilizers than do the general-farms. The use of beet-pulp as dairy feed indirectly induces a farmer to use beet-pulp for fertilizer.
4. A larger and more nearly regular farm income is secured by the dairy-farmer. The regularity of the pay checks from dairy products induces each dairyman to install a system of bookkeeping, which tends to eliminate many losses and unprofitable ventures.

The indirect benefits from dairy-farming are as noticeable as the direct benefits, but less easy to analyze.

1. An economic stability develops, which tends to prevent a farmer from engaging in the disastrous type of crop speculation that is common among the general-farmers. Greater attention is given to the business of the farm, for the demands of dairy stock are so exacting that a farmer must "stay on the job."
2. A desire to improve his farm, his herd, and his financial status is created in a farmer. The monthly inspections of the State Dairy Inspectors forces him to keep his farm and barns clean and sanitary. The necessity of maintaining fences in good condition and friendly rivalry among owners of dairy cattle create a desire to improve the general appearance of the farms.
3. Successful dairy-farming demands study and training. Thus, the habit of reading scientific information is carried on into related farm work. As a result, a dairyman becomes a more successful farmer.

VII. MARKETING ASPECTS

The Uncompahgre Project has been and always will be handicapped by isolation from the commodity markets of the United States. This remote and relatively inaccessible valley, surrounded by rugged mountains, probably always will suffer from a high freight rate structure. Agriculture, in spite of excellent crops

and high yields, is unprofitable largely because of the high cost of transporting produce to market. There is little chance that this situation can be improved in the near future, as the railroads are operating at a loss and cannot lower freight rates.

Railroads

The project is served by two lines of the Denver and Rio Grande Western Railway. A standard-gauge line from Grand Junction runs through the middle of the valley as far south as Montrose. The south and southeastern sections of the valley are served by a narrow-gauge line, which extends from Salida, through Montrose, into southwestern Colorado. This requires the transfer of considerable produce at Montrose, as practically all shipments for eastern markets are routed over the standard gauge line via Grand Junction.

Freight Rates

The high freight rates on the railroads serving the project are, perhaps more than any other thing, responsible for its unsatisfactory economic condition. Apparently nothing can be done, however, to correct the situation. The Denver and Rio Grande Western Railway is virtually bankrupt. The annual deficits are so high that the company has tried for years to dispose of its holdings. Repeated investigations have shown that, from the standpoint of the railroad, the freight rates are fair and equitable. From the standpoint of the producers, they are exorbitantly high, making successful competition with "eastern-slope" farmers almost impossible.

Auto Trucking

The trucking business has increased greatly in the past few years, largely as a result of improved highways in western Colorado. Until recently, the hauling of commodities by truck was unprofitable, because of the poor roads over the two ranges of mountains that separate the project from "eastern-slope" markets. Within a few years, these highways have been greatly improved, and at least one of them is kept open throughout the winter. Trucks provide more rapid service than the railroads, and the more valuable, less bulky commodities, such as fruit, vegetables, onions,

potatoes, and lambs are being trucked more and more to the markets of eastern Colorado. Trucks are making serious inroads into the freight available for the railroads.

Marketing Organization

The project is greatly handicapped by its lack of any unified marketing organization. The farmers, the relatively weak associations, and the small commission agents seek out their own markets and ship their own goods without much co-operation. There are several co-operative associations, but they handle only a small percentage of the goods shipped from the project.

VIII. SUMMARY AND CONCLUSIONS

The Uncompahgre Valley Irrigation Project was undertaken under the provisions of the National Reclamation Act of 1902, with the expectation that the partially-utilized, arid valley would be transformed into a region of prosperous agricultural activity. As a result of the irrigation developments, it was believed that the area would be divided into small farms, upon which homeseekers would settle in such large numbers that the irrigable area would be completely occupied and that the costs of reclamation would be repaid to the Reclamation Fund within ten years. The settlers were expected to co-operate fully with the Government in unifying and furthering the interests of the project.

Most of the hopes and expectations of the proponents of this venture have not materialized. Much land on the project is still held in large blocks, and much of the irrigable area is unworked. Instead of being contented, prosperous farmers, many of the settlers are disillusioned, discouraged, and somewhat antagonistic to the Government. The investment in construction, the expenses of operation and maintenance, and the costs of agriculture are much higher than anticipated. Mortgage indebtedness has increased; taxes and interest rates have risen; marketing problems have multiplied. In spite of frequent, large cancellations in repayments on the project, only a small part of the costs have been repaid to the fund. Repeated financing plans have only postponed a realization that the farmers cannot meet their obligations under existing conditions.

Some reasons for the unsatisfactory state of affairs are obvious; others are obscure and subtle. Whether obvious or obscure, the causal conditions are so interlocked that their ramifications penetrate into all phases of life on the project. It is impossible, in many instances, to separate cause from effect. However, a review is made of the basic factors contributing to the present state of the project:

1. The costs of construction were much higher than had been anticipated and the construction costs levied against each farm unit were therefore much greater than had been promised by the government. That the earning capacity of much of the reclaimed land did not warrant the increased cost is shown by the inability of many of the water-users to meet their annual assessments, by the necessity of extending the repayment period from ten to forty-two years, and by the cancellation of a large part of the total costs. Some of the major reasons for the high final cost followed.
 - a) The cost of constructing the tunnel was almost twice the original estimate. This was due partly to inefficiency, carelessness, and mismanagement in boring the tunnel, and partly to unexpected geologic difficulties encountered in the tunnel.
 - b) The prices paid for the existing canals were much higher than their assessed value and considerably greater than their true value. These high prices were the result of (1) the early failure of the Association to secure control of the major canal systems, (2) the unscrupulous demands of the canal companies, and (3) the unbusinesslike, antagonizing, and vacillating procedure of the government in acquiring the canals.
 - c) The costs of constructing new canals and appurtenant structures and of improving the old ones were much higher than expected. Among the factors involved were (1) the construction of many unnecessary canals and ditches that served only a small farm area, (2) the improper location of many canals, and (3) the necessity for more elaborate features than had been proposed.
2. Operation and maintenance costs have been so high that many water-users have found it almost impossible to meet the annual charges. These high costs are due to (1) the general unsatisfactory layout of the project, which necessitates canals that are large and long in relation to the area of irrigated land served, and (2) certain environmental conditions, such as seepage, alkali, and floods, that damage the canal structures, requiring frequent replacements.
3. Settlement has been slow and unsatisfactory. The expected rush of homeseekers did not materialize. Most of the land on the project was privately owned, and homesteaders found only relatively poor land open for entry. The plight of the early settlers was aggravated by the long delay of the Government in supplying irrigation water. Mortgage indebtedness has increased rapidly as a result of the high water charges and the increase in the price of land, in taxes, and in interest rates. The high percentage of tenancy, together with a large

degree of absentee ownership of land, has had a marked retarding effect on the development of the project.

4. Inaccurate and incomplete surveys by the Government have led to mistrust and misunderstanding on the part of the farmers. Some land that was classified as productive proved to be seeped and alkali impregnated. The early hydrographic surveys that promised an adequate water supply for a much larger area than is being irrigated have proved inaccurate. The water supply has been inadequate for the needs of the farmers, necessitating the rotation of water in different canals. The serious losses in crops resulting from this water shortage have been no higher only because much of the estimated irrigable acreage has not been irrigated.
5. Agriculture in this arid valley is confronted with many serious problems.
 - a) Although the climate is satisfactory for growing irrigated, general farm crops, it is not conducive to the development of specialized, high-value crops. Frosts, cloudbursts, and high winds frequently damage growing crops.
 - b) Although portions of all types of soils on the project produce good crops at times, the soils as a whole are difficult to work and have low productivity. The poorest soils occupy most of the project. The development and expansion of seeped and alkali areas, induced by the inefficient use of water and the unsatisfactory location of portions of the canal systems, have further decreased the productivity of the soils.
 - c) Although individual farmers have attempted to prevent or lessen the damage wrought by seepage and alkali by constructing small drainage ditches, no satisfactory drainage program for the entire project was adopted until recently. The farmers were financially unable to undertake the work, and the government would not undertake it. As a result, large areas of formerly productive land have been ruined and abandoned, or at least, seriously harmed.
 - d) Although many farmers have demonstrated the success of a balanced crop rotation, most of them continue to practice an unscientific crop speculation, usually with unsatisfactory results. In general, little attempt is made to adjust farming and crops to the character of the soils.
 - e) Although numerous insect pests and plant diseases decrease crop yields, no concerted effort has been made to eradicate them. To do so should be a comparatively simple undertaking in this isolated valley.
 - f) Although the irrigable area was subdivided into comparatively small units, the size of these units has not been adjusted to the environment. Many are either too small or too large to be worked efficiently. More detailed surveys and more generous agricultural loans would help to correct the situation.
6. The livestock industry, with which the Uncompahgre Valley has been intimately associated, has not been maintained in its proper position. Situated in the center of extensive grazing ranges in western Colorado, this project should be the nucleus of a livestock industry far greater than has been developed. Instead of capitalizing on its regional advantages, the

project has permitted this industry to decline until it is relatively unimportant.

- a) The beef-cattle industry, of prime importance in the early development of the valley, was seriously crippled by the completion of the Federal Irrigation Project.
 - (1) The land in the large cattle ranches was subdivided, by a ruling of the Reclamation Bureau, into small farm-units. It was later demonstrated that beef-cattle ranching on these small units was unprofitable.
 - (2) It is alleged that the Forest Service, in an attempt to promote a more widely distributed industry on the project, limited the number of grazing permits that one stockman could secure in the nearby National Forests. Eventually, this led to a large decrease in the number of cattle on the project.
 - b) The sheep industry, aided and promoted by the decline in the cattle industry and by the unscientific Stock-Raising Homestead Act, has not proved of great economic value to the project.
 - (1) Much range in the National Forests has been taken over by so-called "foreign" sheepmen from Utah and elsewhere; therefore, relatively few sheep are owned by project farmers. It is alleged that many farmers claim ownership of a large number of sheep and thus secure grazing permits, when in reality they are merely agents for "foreign" sheep companies.
 - c) Dairy farming, which affords the greatest possibility of salvation for the project, has not been popular with most of the farmers. Repeated attempts to promote it have had few permanent results. Most of the dairy stock is of a mixed breed and of inferior quality.
7. The Uncompahgre Project has been handicapped and always will be handicapped by its isolation from important commodity markets. Although served by a broad-gauge and a narrow-gauge railroad and by excellent highways, the difficulties and costs of marketing produce will always retard the development of the project. Situated in a sparsely populated, mountainous country of small production, it is handicapped by high freight rates and poor rail service. The growth of auto trucking has only slightly corrected the situation, and has added to the difficulties of the bankrupt railroad companies in their attempt to provide lower rates and better services.
 8. The failure of the farmers to organize successful co-operative marketing associations has placed them at the mercy of exploiting merchants. The inability of the farmers to produce commodities of distinctly unique character or quality and the lack of any special market emphasis on the general commodities that they do produce is a great handicap.

After several years of investigation, the writer concludes that this reclamation project was sound in principle and worthy of governmental attention. He believes, however, that there was too great emphasis placed on the engineering aspects of supplying water to the land and that too little attention was given to the social

and economic problems upon the solution of which the success of the venture largely depended. Apparently little if any thought was given to the problems of settlement of agricultural procedure, and of marketing.

It is little wonder that the farmers, disillusioned and discouraged from the beginning, have not progressed more rapidly. Yet it cannot be denied that the attitude of the water-users, themselves, has contributed in no small way to the lack of success of the project.

Several suggestions for the improvement of the unsatisfactory status of the project follow:

1. An immediate refinancing program for the farmers should be provided by the Government. This would allow them to escape from the burden of their high mortgage indebtedness and to make necessary improvements on their farms.
2. Long term, low interest loans should be made available to the farmers, in order that they may purchase the livestock, machinery, and other equipment necessary for successful farming.
3. Agricultural efficiency, induced by more careful and adequate direction by trained agents, should be obligatory to securing aid under the refinancing plan. A studied, balanced economy for each farm should be worked out by experts and every effort made to have the farmer adopt it.
4. As a protection to its original investment and as an encouragement to better farming, the government should assume the entire cost of protecting the project from increasing seepage and alkali accumulation.
5. A co-operative marketing association should be created and membership of all farmers on the project be made compulsory, if necessary, in order that produce can be marketed efficiently and with better prospects of profit than at present.

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